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## CONTENTS

The Editor's Page ..... 243

Mr. Callaway Dramatizes Textile Research.

Next Warp Sizing Report in June Issue.

Foundation Officers Re-elected.

Research and Educational Values.

The Base-Combining Capacity of Wool. Milton Harris and Henry A. Rutherford. *A Textile Foundation Publication* ..... 245

Specification of Uniform Color Tolerances for Textiles. Deane B. Judd ..... 253

Textile Industry's Research Needs. Fuller E. Callaway, Jr. 264

A $25,000,000 Plan.

Editorial Comment.

Abstracts ..... 269

Advertisements .....

Henry L. Scott Co., Providence, R. I. ..... 242

U. S. Testing Co., Inc., Hoboken, N. J. ..... 268

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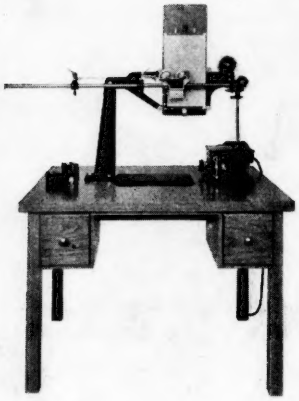

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# The Editor's Page

## Mr. Callaway Dramatizes Textile Research

UNDOUBTEDLY the research needs of the domestic textile industry were properly, and probably adequately, evaluated by Fuller E. Callaway, Jr., at the recent annual meeting of the American Cotton Manufacturers Association, when he suggested the raising of an annual fund of $25,000,000 by textile manufacturers "to promote research on a broad front."

Although it may be possible that Mr. Callaway would be willing to initiate his research plan on the basis of one-tenth of 1% of annual net invoices, nevertheless he would still make this Institute's research efforts look like those of a "bunch of pikers," and those of the Textile Foundation but little more adequate. Probably the Foundation's total expenditure for scientific and economic research and for educational work since its inception in 1930 has not exceeded $500,000, and not a cent of this came from manufacturers.

The Institute's research work has been financed in part by the Foundation and in part by contributions of the industry, the total contributions since the start of the first research in 1934 having been $66,000; of this amount less than $20,000 was contributed by the industry. Meantime, however, the Institute's president proposed a plan for an institute and graduate school of textile research requiring an initial fund of about $1,000,000. This never reached the publicity stage, but is still available as the logical basis for the plan suggested by Mr. Callaway. The latter has now dramatized to the industry the need and possibilities of an adequate research program by coupling them with an annual fund that could not fail to produce the needed results if utilized efficiently. Must the adequate financing of research by the industry be delayed until all major natural fibres have been displaced by synthesized fibres and filaments of equal or superior properties, which are themselves the products of fundamental and applied research?

* * *

## Next Warp Sizing Report in June Issue

THE next of the series of reports of the Institute's completed research on warp sizing of viscose rayon cannot be published in this issue because it includes data that must remain confidential to its subscribers for another month. All results of the Institute's co-operatively financed researches are confidential to the research subscribers for a year. This sixth report of the warp sizing series is entitled "A Photomicrographic Method for Determination of Warp Size Distribution on Viscose Rayon" and will be published in the June issue. It not only describes an improved technique for the staining of starch-sized yarn sections to show size distribution, but makes public for the firt time a reagent and its application for effectively showing the distribution of gelatin sizes.

## Foundation Officers Re-elected

THE following officers of the Textile Foundation were re-elected at the annual meeting in Washington, D. C., April 19: Chairman, Franklin W. Hobbs; Treasurer, Stuart W. Cramer; Secretary and Assistant Treasurer, Edward T. Pickard. It was announced that encouraging reports were presented on the progress of Foundation researches at University of North Carolina, Yale University, Massachusetts Institute of Technology, the National Bureau of Standards, and the Wharton School of Finance and Commerce, University of Pennsylvania. The latter is a study of Textile Inventory Policies and Statistical Guides which is financed by the Foundation and conducted under the auspices of the Committee on Economic Research of U. S. Institute for Textile Research and an advisory group of heads of leading textile associations.

* * *

## Research and Educational Values

THE textile research work and program of the Textile Foundation, and of other textile organizations engaged in research, are to be presented to manufacturers and others associated with the industry in the first of a series of meetings to be held at southern textile schools this week. They will be sponsored by the textile schools, the Textile Foundation, U. S. Institute for Textile Research, and other leading groups of manufacturers and technicians.

The meetings will emphasize textile educational and research values, and among the subjects to be explored and discussed are the following: Merchandising, Management, Progress and Profits from the Laboratory, Training for New Responsibilities, Vertical Integration and Inventory Policies.

The discussions will be led by the following speakers, all of whom are recognized authorities in their particular fields: Hiram S. Davis, Research Department, Wharton School of Finance and Commerce, University of Pennsylvania, director of the study on "Vertical Integration in the Textile Industries"; Warren E. Emley, National Bureau of Standards, member of the Textile Foundation's Advisory Committee for Scientific Research, and former chairman of the Research Council of U. S. Institute for Textile Research; Frederick M. Feiker, General Secretary, American Engineering Council, author of "Training of Men for the Textile Industry"; Stanley B. Hunt, Textile Economics Bureau, member of the Economic Research committee of the U. S. Institute for Textile Research; George W. Taylor, Research Department, Wharton School of Finance and Commerce, University of Pennsylvania, member of the Textile Industry Committee of the Wage and Hour Administration.

This series of meetings, which will be followed next fall by a similar series in the North, will be held at 2:30 P.M., at the following places and dates: Alabama Polytechnic Institute, Auburn, Ala., Monday, May 1, Broun Hall; Georgia School of Technology, Atlanta, Ga., Tuesday, May 2, Y. M. C. A. Building; Clemson College, Clemson, S. C., Wednesday, May 3, Engineering Building Auditorium; N. C. State College, Raleigh, N. C., Friday, May 5, College Y. M. C. A.

Everyone interested is invited to attend the most convenient meeting and to take part in the discussions.

# The Base-Combining Capacity of Wool

By MILTON HARRIS and HENRY A. RUTHERFORD *

*A Textile Foundation Publication*


## Abstract

*It is shown that the failure of wool to reach equilibrium with alkaline solutions under the conditions of titration experiments is due to the reaction of base with the disulfide groups of the cystine. The results indicate that the extent of this reaction can be determined. The data also afford confirmation of the earlier observation that the alkali degradation of the cystine in wool involves the loss of only one sulfur atom from each cystine residue.*

*The apparent base-combining capacity increases with increasing duration of contact of wool with alkali and with increasing temperature, but the intrinsic base-combining capacity, obtained by making corrections for the dissolved protein and for the base bound by the sulfhydryl groups, becomes constant after approximately two hours. The most consistent data are obtained at a low temperature where, it appears, secondary reactions are greatly inhibited.*

*Determination of the amount of base absorbed from solutions of various concentrations indicates that a limiting amount of about 0.7 millimole per gram of wool is reached above concentrations of about 0.2 N sodium hydroxide. Because of discrepancies in the data obtained at concentrations greater than 0.3 N, it is suggested that this value be considered for the present as tentative.*


## I. Introduction

MANY properties of wool are intimately related to the number of acidic and basic groups which it contains. Because of the stability of wool in acid solutions, few difficulties are encountered in determining the acid-combining capacity, which apparently reaches a maximum of about 0.80 millimole per gram of wool at about pH 1.[1] In the alkaline region, however, there has been no indication of a maximum base-combining capacity or of a stoichiometric end-point, and as a result very little knowledge concerning the number of acidic groups in wool can be deduced from published titration data.

The results of recent investigations by Crowder and Harris[2] on the nature of the degradation of wool protein in alkaline solutions suggested that the chief difficulty in determining the base-combining capacity arises

* Research Associates at the National Bureau of Standards for the Textile Foundation, Inc. This is the first publication of the new research program of the Textile Foundation at the National Bureau of Standards.

from the fact that the alkali reacts not only with the free acidic groups, but also with the disulfide groups of the cystine in the protein. It appears that the primary process in the cleavage by alkali of the disulfide linkage consists in a hydrolytic rupture with the formation of a sulfhydryl compound and a sulfenic acid. The latter is unstable in alkaline solution and immediately loses hydrogen sulfide. The general scheme is given in the following equations:

$$RCH_2 — S — S — CH_2R + 2NaOH \rightarrow RCH_2S\,Na + RCH_2SONa + H_2O \quad (1)$$

$$RCH_2SONa \rightarrow RCHO + NaHS \quad (2)$$

The sulfhydryl and sulfenic compounds, formed according to Eq. 1, are both acidic and accordingly, 2 moles of base are taken up in the cleavage of each disulfide group. However, 1 mole is liberated in the breakdown of the sulfenic acid, as shown in Eq. 2. If the above mechanism is correct, the amount of inorganic sulfide sulfur (NaHS) formed during treatment of wool with a basic solution should be a measure, not only of the number of disulfide groups hydrolyzed, but also of the amount of base taken up by the sulfhydryl group formed in the wool.

The purpose of the present investigation was to study the absorption of base by wool from the viewpoint of the above hypothesis. It was intended that these studies form a background for the investigation of the basic portion of the complete titration curves.

## II. Experimental

*Materials.*—It has been demonstrated in this laboratory and elsewhere [2] that the disulfide group of the cystine in wool is readily attacked by light. Since it was necessary to know the number of disulfide groups which were split during the alkali treatment of the wool, considerable care was exercised in choosing suitable samples for these measurements. Obviously, it was particularly desirable to have the bulk of the sulfur in the form of intact disulfide groups.

Two types of materials were used in these experiments: namely, raw wool fibres and a specially prepared wool yarn. The former were divided into three approximately equal sections, which were designated as the root, middle, and tip portions of the fibre. Each portion was purified by extraction with alcohol and ether and finally washed with distilled water. The analyses given in Table 1 show that both the sulfur and cystine contents

TABLE 1

The sulfur and cystine contents of the root, middle, and tip portions of wool fibres.

| Sample | Total sulfur | Cystine found | Cystine* calculated | Total sulfur as cystine sulfur |
|---|---|---|---|---|
| Root | 3.46 | 12.6 | 12.9 | 97 |
| Middle | 3.32 | 11.8 | 11.9 | 95 |
| Tip | 3.12 | 9.9 | 10.4 | 85 |

* Calculated from total sulfur assuming that the destruction of each molecule of cystine involves the loss of only one atom of sulfur.

decrease from the root to the tip of the fibre, but that only in the tip portion has an appreciable amount of the cystine been destroyed.

The yarn was prepared from raw wool, which had been extracted with Stoddard solvent and washed with water. It was further purified as described above. Determination of the total sulfur and cystine contents showed that 97% of the former could be accounted for as cystine sulfur, thus indicating that very little photochemical deterioration had occurred. The data reported in this work were obtained on root wool or yarn.

*Methods.*—The complete experimental procedure was as follows. Samples of wool weighing approximately 1 g. were dried in an oven at 105° C. After drying, each sample was weighed and treated with 50 ml. of a sodium hydroxide solution at 0°–2° C (air bath) or 22° C. At the end of a given time, the supernatant liquor was poured off. A 5-ml. aliquot was taken for nitrogen analysis, a 20-ml. aliquot for inorganic sulfide sulfur analysis, and a 20-ml. aliquot for volumetric titration with hydrochloric acid, using methyl red as the indicator. In some of the experiments, an excess of a cold solution of 0.1 *N* hydrochloric acid was immediately added to the residual wool to prevent further degradation of the fibres. The fibres were allowed to remain in the acid for one day and were then washed for four days in running distilled water. Finally, the cystine content of each sample was determined.

Nitrogen was determined by the micro-Kjeldahl method, total sulfur by the oxygen bomb method,[4] and cystine by the Sullivan method.[5] In the latter determination, the wool was hydrolyzed with a hydrochloric-formic acid mixture as described by Miller and duVigneaud [6] and the color measured by the method described by Harris and Smith.[7]

The inorganic sulfide sulfur was determined by the following procedure. An excess of bromine was immediately added * to the solution. The mixture was allowed to stand for several minutes, then acidified with hydrochloric acid, and finally warmed on a steam bath until free from bromine. The sulfate was precipitated as the barium salt and determined in the usual manner.

The apparent base-combining capacity is the value obtained directly from the measurement of the total amount of sodium hydroxide removed from the solution by the wool. The intrinsic base-combining capacity is the amount of base bound by the free acidic groups of the undegraded wool. To obtain this, two corrections must be introduced. One of these is small but the other will be shown to be very important.

The first correction, which is the less important, results from the conversion of a portion of the original wool into a soluble form during the treatment with alkali. Since methyl red was used as the indicator, the base bound by the dissolved material is neutralized during the titration. In order to correct for this effect and to obtain only the absorption by the insoluble portion of wool, it is necessary to subtract the weight of the soluble fraction from the original weight of the untreated material. The former is readily calculated from the nitrogen in the solution since it has previously been shown [8] that the loss of nitrogen from wool during alkaline treatment is proportional to the loss in weight of the wool.

The second correction is for the base bound by sulfhydryl groups formed in the degradation of the disulfide groups of the cystine according to Eqs. 1 and 2. The amount of base taken up as a result of these re-

* Sulfur in wool or in cystine is not oxidized to sulfate under these conditions.

actions is calculated from the inorganic sulfide sulfur which has gone into solution.

## III. Results and Discussion

*1.—Effect of sodium hydroxide on the cystine in wool.* The mechanism suggested [2] for the alkali degradation of the cystine in wool involves the loss of only one sulfur atom for each disulfide group. In order further to test this hypothesis, a series of wool samples was treated with a 0.1 *N* solution of sodium hydroxide for different lengths of time at 0°–2° C and 22° C, the solutions and wool being handled as previously described. The effect of the treatment on the cystine is shown in Table 2. Good agreement

TABLE 2

The degradation of cystine in wool by 0.1 *N* solutions of sodium hydroxide at 0°–2° C. and at 22° C. as a function of time.

| Time | 0°–2° C. | | | 22° C. | | |
|---|---|---|---|---|---|---|
| | Inorganic sulfide sulfur in solution | Cystine | | Inorganic sulfide sulfur in solution | Cystine | |
| | | Calc.* | Expt. | | Calc.* | Expt. |
| hrs. | mg/gm of wool | % | % | mg/gm of wool | % | % |
| 0 | — | — | 12.1 | — | — | 12.3 |
| 0.5 | 0.44 | 11.8 | 11.8 | 1.10 | 11.5 | 11.9 |
| 1.0 | .46 | 11.8 | 11.9 | 1.49 | 11.2 | 11.3 |
| 1.5 | .50 | 11.7 | 11.5 | 2.21 | 10.6 | 10.9 |
| 2 | .62 | 11.6 | 11.6 | 2.70 | 10.2 | 9.9 |
| 3.25 | .71 | 11.6 | 11.5 | 3.80 | 9.4 | 9.1 |
| 5 | .82 | 11.5 | 11.4 | 5.02 | 8.5 | 8.9 |
| 6.5 | .98 | 11.4 | 11.2 | — | — | — |
| 8 | 1.14 | 11.2 | 11.3 | 6.18 | 7.7 | 7.7 |
| 20 | 2.27 | 10.4 | 10.2 | 9.34 | 5.3 | 6.1 |
| 48 | 3.85 | 9.2 | 9.0 | 12.12 | 3.2 | 5.0 |
| 90 | 6.02 | 7.6 | 8.1 | 14.00 | 1.8 | 4.2 |
| 240 | 9.36 | 5.1 | 6.3 | — | — | — |

* These values were calculated on the basis that each atom of inorganic sulfide sulfur found in solution represented the destruction of a molecule of cystine.

was obtained between the experimentally determined cystine values and those calculated from the loss in sulfur. Appreciable discrepancies occurred only in the experiments in which the wool was severely degraded by prolonged contact with the alkali.

*2.—The absorption of alkali as a function of time.* The time necessary to attain equilibrium was determined by measuring the absorption of base from 0.1 *N* solution of sodium hydroxide. The data given in Tables 3 and 4 were obtained at 0°–2° C and 22° C respectively.

Fig. 1 shows that at 0°–2° C the apparent base-combining capacity increased with increasing time of treatment whereas the intrinsic base-combining capacity became constant after about two hours. The former arose,

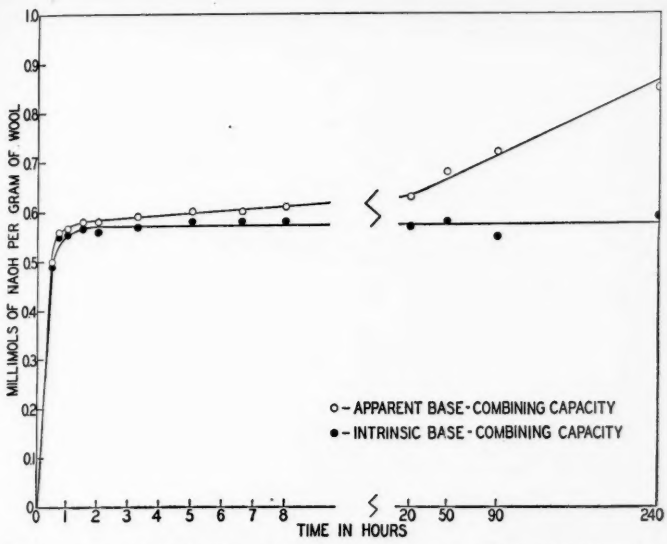


FIG. 1. Rate of absorption of base from 0.1 *N* solutions of sodium hydroxide at 0°–2° C.

as shown in column 5 of Table 3, from the combination of the base with sulfhydryl groups which were continuously formed in the degradation of the cystine. The amount of base which reacted in this manner increased with increasing time of treatment. After 240 hours, the correction amounted to 35% of the apparent value. On the other hand, the correction for the dissolved protein was negligible up to 5 hours and mounted to only 0.03 millimole per gram of wool after 240 hours. The constancy of the corrected values is shown in column 6, and indicates the absence of appreciable secondary reactions.

The intrinsic base-combining capacities obtained at 22° C, as shown in Table 4, appear to be somewhat lower and considerably more erratic than those obtained at 0°–2° C. This may be attributed to several factors. The rate of degradation, as indicated by the amount of dissolved nitrogen (column 1, Tables 3 and 4) was much greater at the higher temperature; for example, approximately the same amount of degradation occurred in 3¼ hours at 22° C as occurred in 48 hours at 0°–2° C. It was also noticed that the reproducibility of the titrations decreased as the amount of degradation increased. The chief difficulty appeared to result from the effect of the dissolved protein on the sharpness of the end-point. Finally, an error was introduced since some sulfhydryl groups were probably present in the dissolved protein. The base bound by these groups was neutralized on addition of acid, and since the data in column 5 were calculated on the assumption that all of the sulfhydryl groups formed according to Eqs. 1

TABLE 3

The absorption of base from 0.1 *N* solutions of sodium hydroxide at 0°–2° C. as a function of time.

| Time | 1 Nitrogen in soln. | 2 Inorganic sulfide sulfur in soln. | 3 Apparent base-combining capacity | 4 Base-combining capacity corrected for dissolved protein | 5 Base bound by sulfhydryl groups formed according to Eqs. 1 & 2 | 6 Intrinsic base-combining capacity (4–5) |
|---|---|---|---|---|---|---|
| hrs. | mg/gm* | mg/gm | millimols/gm | millimols/gm | millimols/gm | millimols/gm |
| 0.50 | .52 | .44 | .50 | .50 | .014 | .49 |
| 0.75 | .54 | .40 | .56 | .56 | .013 | .55 |
| 1.00 | .71 | .46 | .57 | .57 | .014 | .56 |
| 1.5 | .93 | .50 | .58 | .58 | .016 | .56 |
| 2 | .92 | .62 | .58 | .58 | .019 | .56 |
| 3.25 | 1.20 | .71 | .59 | .59 | .022 | .57 |
| 5 | 1.42 | .82 | .60 | .61 | .026 | .58 |
| 6.5 | 1.56 | .98 | .60 | .61 | .031 | .58 |
| 8 | 1.94 | 1.14 | .61 | .62 | .036 | .58 |
| 20 | 2.61 | 2.27 | .63 | .64 | .071 | .57 |
| 48 | 3.70 | 3.85 | .68 | .70 | .120 | .58 |
| 90 | 4.57 | 6.02 | .72 | .74 | .188 | .55 |
| 240 | 5.47 | 9.36 | .85 | .88 | .293 | .59 |

* All values in this table are in terms of grams of dry wool.

TABLE 4

The absorption of base by wool from 0.1 *N* solutions of sodium hydroxide at 22° C. as a function of time.

| Time | 1 Nitrogen in soln. | 2 Inorganic sulfide sulfur in soln. | 3 Apparent base-combining capacity | 4 Base-combining capacity corrected for dissolved protein | 5 Base bound by sulfhydryl groups formed according to Eqs. 1 & 2 | 6 Intrinsic base-combining capacity (4–5) |
|---|---|---|---|---|---|---|
| hrs. | mg/gm* | mg/gm | millimols/gm | millimols/gm | millimols/gm | millimols/gm |
| .5 | 1.05 | 1.10 | .54 | .54 | .034 | .51 |
| 1.0 | 1.86 | 1.49 | .61 | .62 | .047 | .57 |
| 1.5 | 2.31 | 2.21 | .59 | .60 | .069 | .53 |
| 2.0 | 2.91 | 2.70 | .61 | .62 | .084 | .54 |
| 3.25 | 3.66 | 3.80 | .63 | .65 | .119 | .53 |
| 5 | 4.18 | 5.02 | .64 | .66 | .157 | .50 |
| 8 | 4.73 | 6.18 | .70 | .72 | .193 | .53 |
| 20 | 6.43 | 9.34 | .74 | .77 | .293 | .48 |
| 48 | 7.00 | 12.12 | .80 | .84 | .378 | .46 |
| 90 | 10.5 | 14.00 | .94 | 1.00 | .438 | .56 |

* All values in this table are in terms of grams of dry wool.

and 2 bind base, these values may be too large. In the case of the low-temperature experiments, and especially for the shorter periods of time, this error is shown to be negligible (Table 3). However, at 22° C the amount of protein which goes into solution may contain a sufficient number of sulfhydryl groups to account for a large portion of the discrepancy between the values obtained at this temperature and those obtained at 0°–2° C.

*3.—Absorption of base from solutions of various concentrations.* The effect of varying the concentration of base is shown in Fig. 2. The absorp-

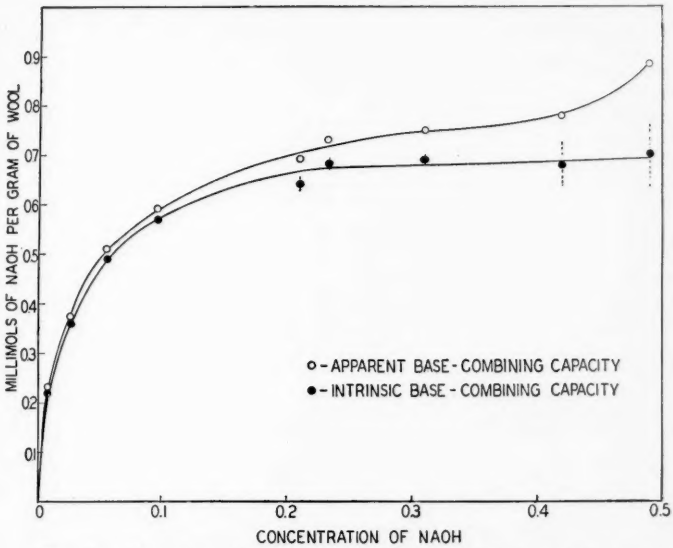


FIG. 2. Absorption of base from solutions of various concentrations. The broken vertical lines indicate the maximum variations in the values obtained.

tions were measured at 0°–2° C, 2 hours being allowed to attain equilibrium. That equilibrium was reached under these conditions in the most dilute and most concentrated solutions used was indicated by measurements made after 2 and 20 hours.

Each point represents the average of four determinations. Good agreement between the individual determinations for each concentration of alkali up to about 0.3 *N* was obtained. Above that concentration, there was considerable variation as indicated by the dotted lines perpendicular to the lower curve, which show the spread of the values obtained. The discrepancies may have resulted from secondary reactions which occurred in the strongly alkaline solutions or from the small temperature variations in the air bath used in this work.

The amount of base combined changes very little when the concentration of base exceeds 0.2 *N* and appears to approach a limiting value of about 0.70 millimole of base per gram of wool.

## IV. Conclusions

The results of the present study show that the failure of wool * to reach equilibrium with alkaline solutions under the conditions of titration experiments is due to the reaction of base with disulfide groups of the cystine. It is demonstrated that the extent of this reaction can be determined.

The data afford confirmation of the earlier observation [2] that the alkali degradation of the cystine in wool involves the loss of only one sulfur atom from each cystine molecule. The remaining sulfur is apparently present in the form of sulfhdryl groups. On the basis of this mechanism it is possible to calculate the amount of base taken up in the degradation of the disulfide groups.

The apparent base-combining capacity increases with increasing duration of contact of wool with alkali and with increasing temperature of the alkaline solutions, but the intrinsic base-combining capacity, obtained by making corrections for the dissolved protein and for the base bound by the sulfhydryl groups, becomes constant after approximately two hours. The results show that the more consistent data are obtained at the lower temperature where, it appears, secondary reactions are greatly inhibited.

Determination of the amount of base absorbed from solutions of various concentrations indicates that a limiting amount of about 0.7 millimole per gram of wool is reached above concentrations of about 0.2 *N* sodium hydroxide. Since some discrepancies occur in the data obtained at high concentrations of alkali, and since the possible influence of the naturally-occurring ash have not been considered, it is suggested that this value be considered for the present as tentative.†

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* This demonstrably applies to other cystine-containing proteins.

† Further work, in which experiments are being made in a water thermostat which can be regulated to 0.02° C, is now in progress. The effect of the ash is also being studied. For these reasons, a discussion of the stoichiometry of the reaction of base with the free acidic groups in wool is not presented at this time.

# Specification of Uniform Color Tolerances for Textiles*

By DEANE B. JUDD†

## Abstract

*Work on methods of specifying uniform color tolerances for various materials has been going on at the National Bureau of Standards for several years. This paper describes the progress of this work, particularly as it relates to textile materials which offer special complications of their own.*

*A formula for the purpose of expressing the size of color differences is derived for observing conditions characteristic of the color inspection of textiles. This formula is based upon the standard observer recommended in 1931 by the International Commission on Illumination and upon a coordinate system (the uniform-chromaticity-scale system) intended to give equal spacing for equally perceptible chromaticity differences. An instrument designed particularly for the measurement of small chromaticity differences is described, together with its calibration in terms of the uniform-chromaticity-scale system. The chromaticity differences between 15 representative pairs of dyed woolen textiles supplied by the duPont Technical Laboratory have been measured by means of this instrument; lightness differences for the 15 pairs were evaluated by measurements of luminous apparent reflectance with a photoelectric reflectometer, and the color-difference formula has been applied to combine the chromaticity and lightness differences to form computed values of the color difference. These computed differences are compared with those obtained at the duPont Technical Laboratory by direct visual estimate and with differences similarly obtained at the National Bureau of Standards. Results by the formula have also been compared with two other proposals (Nutting, Nickerson) for evaluation of color differences between textile samples. It is concluded that the present formula agrees with direct visual estimate for the samples tested except for certain deep reds and blues. Some of these deviations are irregular, and possible reasons for the failure of the formula to apply to these samples are discussed. A majority of them are regular, however, and suggest how the formula can be improved to make it sufficiently accurate for practical and convenient specification of color tolerances for these colors also.*

## I. Introduction

IN the purchase of dyed textiles, it has long been customary to specify the color desired merely by stating "like sample." The advantage of actual measurement of the sample by the spectrophotometer and specification of the desired color within a previously agreed upon tolerance has

* Presented before Committee D–13, Subcommittee B–4, A. S. T. M., March, 1938.

† Physicist, National Bureau of Standards, Washington, D. C.

been pointed out by Nutting[1] who proposed that the color tolerances for each type of material, each color, and each separate character of color difference be specified in terms of the standard observer and colorimetric coordinate system recommended in 1931 by the International Commission on Illumination (ICI).[2] The three parameters suggested by Nutting are daylight (ICI illuminant C) reflectance, dominant wave length, and excitation purity; these are psycho-physical terms approximately correlative with lightness, hue, and saturation of the corresponding color.

A system of specifying color tolerances by a single number intended to be proportional to the perceptibility of the color difference was proposed by Nickerson[3] who used spectrophotometric measurements on samples of the Munsell Color System,[4] made by Glenn and Killian in Professor A. C. Hardy's laboratory at the Massachusetts Institute of Technology,[5] as a guide to size of color differences expressed in the 1931 ICI colorimetric coordinate system. The Munsell system is intended to embody scales of uniform color spacing, and does embody them to a degree not possessed by any other general system of material color standards; the system is therefore well suited to the immediate practical solution of the problem of color tolerances for surface colors viewed in daylight. This system is the basis of the Nickerson index of fading and of her method of specifying color tolerances generally.

The purpose of the present paper is to describe and test a method of specifying uniform color tolerances of a somewhat wider applicability than the Nickerson index of fading; that is, the method will apply to surface colors obtained under illuminants other than daylight as well as to those under daylight. Furthermore, it will deal with all surface colors, however saturated, as conveniently as with those falling among the Munsell colors.

## II. Derivation of the Formula for Color Difference

The basic idea by means of which this formula for size of differences among surface colors was derived is that Euclidean geometry can be applied; that is, it is assumed that it is possible to represent surface colors by points so arranged as to make up a solid figure, known as the surface-color solid, within which Euclidean distances between points are proportional to the size or perceptibility, $\Delta E$, of the color difference between the colors represented by the points. That this is by no means axiomatic may be seen by the recent conclusion by Silberstein[6] that the color three-fold cannot be represented faithfully by a portion of ordinary space except by a failure of Fechner's law to apply. However, we consider the possibility of using Euclidean space worth exploring; first, because the Fechner law may really not apply closely, and, second, because the Munsell system, itself, which is at least a good first approximation to the facts, is an Euclidean arrangement.

The first assumption on which the formula depends is that surface colors of the same lightness (Munsell term: value) can be represented on horizontal planes in the surface-color solid, and that variations in lightness at constant chromaticity[7] (chromaticity of a chromatic color is determined by the hue and saturation attributes of the color) are to be represented along lines perpendicular to the constant-lightness planes. This assumption

is also a part of the Munsell system. If we have, therefore, two colors, $E_1$ and $E_2$, having lightnesses, $L_1$ and $L_2$, and chromaticities, $C_1$ and $C_2$, this assumption yields by ordinary geometry the familiar distance formula.

$$(E_1 - E_2)^2 = (L_1 - L_2)^2 + (C_1 - C_2)^2$$

or, in the difference notation which we shall use hereafter:

$$\overline{\Delta E}^2 = \overline{\Delta L}^2 + \overline{\Delta C}^2 \tag{1}$$

The second assumption is that the true relation connecting lightness of the surface color with the luminous apparent reflectance, A, (for definition of apparent reflectance see [8]) of the surface departs only by a negligible amount from the square-root relation; that is, we assume that:

$$L = k_1 A^{\frac{1}{2}} \tag{2}$$

or, in difference form

$$\Delta L = k_1 \Delta(A^{\frac{1}{2}}) \doteq (k_1/2)(\Delta A/A^{\frac{1}{2}}) \tag{2a}$$

Lightness is a function not only of the luminous apparent reflectance of the sample but also a function of that of the background against which it is viewed.[9] The formula proposed by Godlove [9] is probably the most accurate available; but we have chosen the simple relation (2) as a convenient approximation for both light and medium backgrounds because it is desired to have the formula for color difference apply not to any particular background but to average viewing conditions. Equation (2) is a special case of the Godlove formula for luminous apparent reflectance of the background equal to unity; it also falls nearly within the spread of observers for a middle gray background.[10]

The third assumption deals with the use of the uniform-chromaticity-scale triangle [11] derived for the purpose of providing uniform spacing for all pairs of colors of constant brightness whose differences are equally perceptible; this triangle is shown in Fig. 1. Although the experimental data from which this particular transformation of the standard 1931 ICI colorimetric coordinate system was derived are chiefly aperture colors of small angular extent (confined to the macula lutea) it is assumed that this triangle applies sufficiently closely to differences between surface colors of the same lightness viewed so as to subtend a large visual angle (not confined to the macula). This assumption would permit us to write for chromaticity difference, $\Delta C$, between colors of any one lightness:

$$\Delta C = k_2 \Delta S \tag{3}$$

where: $\overline{\Delta S}^2 = (r_1 - r_2)^2 + (g_1 - g_2)^2 + (b_1 - b_2)^2$, the trilinear coordinates of the first color being $(r_1, g_1, b_1)$ and those of the second $(r_2, g_2, b_2)$.

The fourth assumption has to do with the experimental fact that, under ordinary conditions of inspecting textile samples for color, a given chromaticity difference corresponds to a larger trilinear-coordinate difference for dark samples than for light. It is assumed that equation (3) extended to colors of all lightnesses should be written:

$$\Delta C = k_2 A^{\frac{1}{2}} \Delta S \tag{4}$$

This formula would state that a deep "red" is not a perceptibly different color from a deep "green," provided the surfaces exemplifying them have

sufficiently low luminous apparent reflectances. The reason why the eye could not detect the color difference between two such samples both of which would appear black is that the relatively much stronger stimulation of

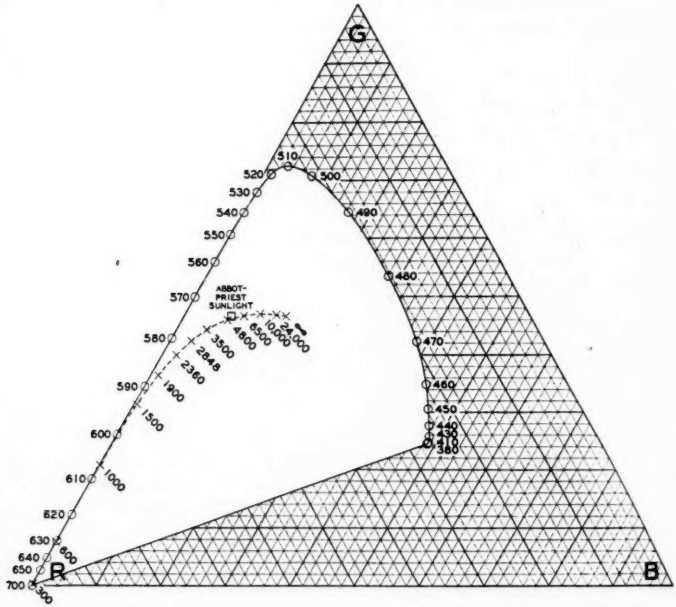


FIG. 1. The uniform-chromaticity-scale triangle. Wave length along the spectrum locus is indicated in millimicrons; color temperature along the Planckian locus is given in degrees Kelvin.

neighboring retinal areas prevents it by irradiation and contrast effects. Equation (4) like equation (2) holds, therefore, most closely for inspection of samples under the ordinary condition that the surrounding field is lighter than dark samples, but if precautions were taken to have no part of the retina receive greater illumination than the part on which the image of the two samples falls, then equation (4) would not hold; on the contrary, equation (3) would probably apply to colors of all lightnesses without restriction. The reason for choosing the fourth root of the apparent luminous reflectance A in equation (4) rather than some other function of A is first because of its simplicity, and second because the samples of the Munsell system approximately follow this relation.

A special precaution should be noted, however, as to strict applicability of equation (4): it is not in accord with the first assumption. If equation (3) had been extended without change to colors of all lightnesses, the resulting formula for color difference would be entirely consistent with an

Euclidean arrangement. The inclusion of the $A^{\frac{1}{2}}$ term in equation (4), however, makes the lines of constant chromaticity, in general, cut the planes of constant lightness at an angle increasingly different from a right angle as A approaches zero; equation (1) becomes less and less strictly applicable as we pass toward darker colors. In order to satisfy equation (1), constant chromaticity would have to be identified with a series of points on the U.C.S. triangle for different lightnesses as is done in the Munsell system rather than with a single point as is done in formula (4). Whether it will be necessary to use the more complicated formula found by applying Euclidean geometry more strictly, remains to be decided by experiment.

By substitution of (2a) and (4) in (1), for $k_1 = 120$ and $k_2 = 600$, we obtain the formula for size of color difference which is to be tested for conformity to the results of direct visual estimates.

$$\Delta E = 600\,[A^{\frac{1}{2}}\,\overline{\Delta S^2} + 0.04\,\overline{\Delta(A^{\frac{1}{2}})^2}]^{\frac{1}{2}} \tag{5}$$

$$= 600\,[A^{\frac{1}{2}}\,\overline{\Delta S^2} + 0.01\,\overline{\Delta A^2}/A]^{\frac{1}{2}} \tag{5a}$$

The ratio of the constants $k_1$ and $k_2$ has to be adjusted so as to evaluate lightness differences relative to chromaticity differences in the same way as the average inspector of textiles weights them. The ratio 120:600 is a tentative choice based on a few preliminary experiments. The sum of the constants determines the size of the unit of color difference; it has been adjusted with the intention of choosing a unit color difference of such size that smaller differences can be neglected in the average commercial transaction involving a color match, but larger differences cannot. This adjustment is also tentative; it gives 120 units of color difference from black to white, and about 300 units between the strongest possible red and the strongest possible green for samples of apparent daylight reflectances of 0.10.[12] This makes the surface-color solid a rather squat figure, the maximum horizontal dimension being nearly 3 times that of the maximum vertical dimension.

Equation (5), the strict consequence of the four assumptions, is applicable to all color differences, however great. Equation (5a) is applicable to color differences of the order of 2 units and is more convenient than (5) because by using it one may avoid the extraction of square root to 4 significant figures. For $\Delta E$ less than 2 units it does not make a significant difference in the evaluation of the chromaticity term which sample is referred to by the $A^{\frac{1}{2}}$ factor, but when equation (5) has to be used the average value of $A^{\frac{1}{2}}$ for both samples is meant.

## III. The Chromaticity-Difference Colorimeter

The differences in luminous apparent reflectance between samples used in the testing of equation (5) have been determined on the multipurpose reflectometer.[13] The differences in chromaticity estimated from equation (4) have been determined from trilinear-coordinate differences obtained by means of a subtractive colorimeter especially designed for the detection of small chromaticity differences.[14]

## A. Description

Fig. 2 shows the essential parts of this colorimeter. A 400-watt projection lamp at a color temperature of about 3,100° K, movable between the standard and comparison surfaces, illuminates them perpendicularly. These surfaces are viewed at 45° and brought into optical juxtaposition by a Lummer-Brodhun cube bearing the usual double-trapezoid pattern. The sample size required to fill the 9° x 13° photometric field may be varied from 10- to about 1-cm diameter by appropriate lenses, but for the textile samples dealt with here a sample size of about 4-cm diameter was used. Except for these clear optical elements, and a filter of Corning Daylite glass to be discussed presently, the observer views the standard directly, but he views the comparison surface through two double wedges, one of greenish, the other of yellowish glass. The thickness of each wedge traversed by the comparison beam may be varied by the observer until a complete color match is possible. The filter of Corning Daylite glass has been adjusted in thickness so as to raise the color temperature of the source to about 6,500° K, which makes the source-and-filter combination a close representation of average daylight. At first this filter was placed over the artificial pupil as shown in Fig. 2, but it was found that many textile samples changed

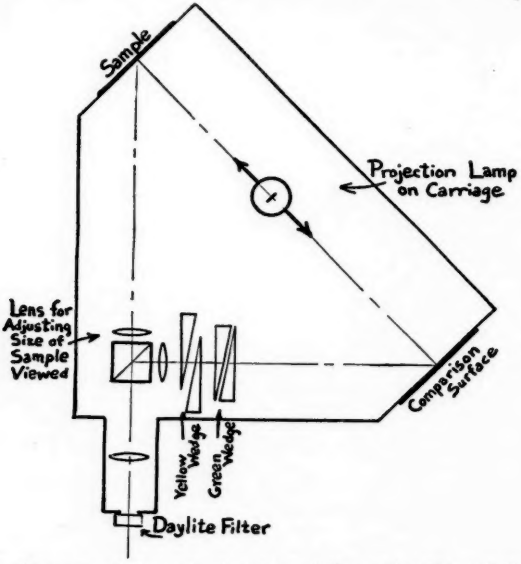


FIG. 2. Diagram of the optical system of the subtractive colorimeter.

color importantly when exposed to the heat of the 400-watt lamp which is only a few inches away from the sample; accordingly the small ocular filter was removed, and two 8-cm square pieces of Corning Daylite glass, both of

the same thickness as the ocular filter, were mounted close to the source in the two illuminating beams and were protected from overheating by pieces of Corning Aklo heat absorbing glass, the whole unit being cooled by a blower not shown in Fig. 2. This arrangement gives about the same brightness in the photometric field as does the use of the ocular filter but reduces to about 1/10th the amount of radiant energy incident upon sample and comparison surface.

To get an indication of the chromaticity difference between a sample and a standard in terms of the wedge settings, a comparison surface is chosen which is near (preferably intermediate) in spectral apparent reflectance to both sample and standard. The wedges are first adjusted to match the standard; then the sample is substituted and the wedges reset. If the sample is yellower or greener than the standard the thickness of one wedge or the other will have to be increased to produce a match; but if it is redder or bluer the thickness will have to be decreased. During the process of matching the observer adjusts the position of the lamp in such a way as to bring out most definitely any chromaticity difference between the two parts of the photometric field. This adjustment has been found for most observers not to be to equal brightness of the two parts of the field. It has been found considerably better to oscillate the brightness about the position of equality with a period of approximately one second. Because of the large, patterned field, the high brightness, and the convenient brightness adjustment, this instrument takes full advantage of the chromaticity sensibility of the observer. It has been found that a mean of two settings of the wedges is uncertain by an amount corresponding to not more than 0.0003 in r, g, or b on the uniform-chromaticity-scale triangle for light samples.

This instrument has proved useful in measuring the several hundred small chromaticity differences between samples which have been used in testing out formula (5) and allied formulas. It is used in preference to the spectrophotometer because of the superior speed and convenience; but it should be pointed out that the subtractive colorimeter is not an independent substitute for the spectrophotometer because it requires spectrophotometric calibration both of the wedges and of the comparison surfaces, as explained later. Once calibrated, however, the subtractive colorimeter is more rapid in the determination of small chromaticity differences even than the G.E. recording spectrophotometer. The use of the latter instrument requires each pair of curves (sample and standard nearly identical) to be drawn on a separate sheet; this takes about 10 minutes. Then the data on the curve sheet must be reduced. The most rapid method is the addition of three sets of 10 selected ordinates[15, 2] for each sample. To read, add, and check the 60 ordinates required for each pair of samples takes another 20 minutes. Transformation to the U.C.S. system and application of formula (5) require 10 more minutes for each sample pair provided they are done in large groups, say ten, which speeds up the computation. This is an average of 40 minutes per difference. To obtain the same information with the same or better precision by means of the photoelectric reflectometer and the subtractive colorimeter requires about half this time, divided as follows: 2 minutes per difference on the photoelectric reflectometer, 8 minutes per difference on the subtractive colorimeter, 10 minutes per difference for reducing and checking the data, making an average of 20 minutes per difference.

Work is also in progress on a photoelectric tristimulus colorimeter for

these same purposes which it is hoped will prove equally reliable.[16] A formula analogous to (5) may be evaluated by this instrument in an average time of but 12 minutes per difference.

## B. Calibration

For the purpose of determining the trilinear-coordinate differences between sample and standard, it is necessary to know approximately the spectral apparent reflectance of the comparison surface. This permits the instrument to be calibrated in terms of any fundamental colorimetric coordinate system. The calibration consists of a computation by the usual methods[2, 11] of the trilinear coordinates of the comparison surface illuminated by artificial daylight and viewed both directly and through a known thickness of the glass making up one of the double wedges. This computation requires that the spectral transmissions of the double wedges be known. The bluish green glass of one double wedge is Corning Aklo glass; the

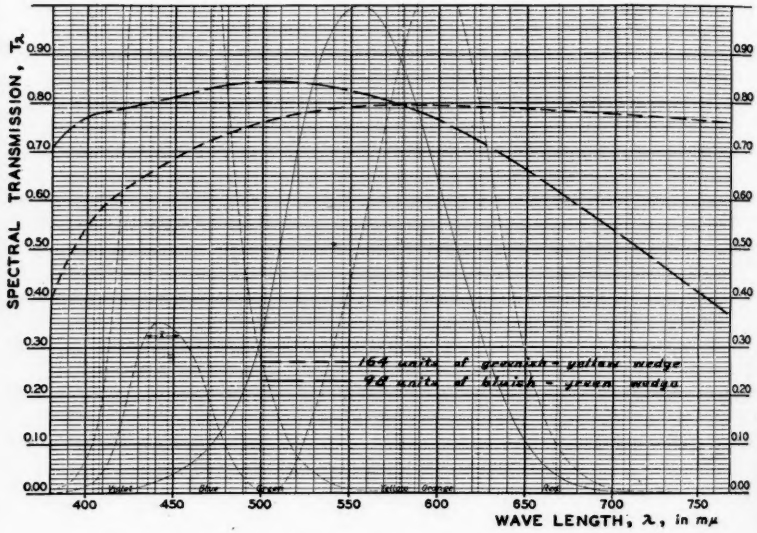


FIG. 3. The spectral transmission of the two pairs of double wedges used in the subtractive colorimeter. Thicknesses of the glasses are expressed in (arbitrary) wedge units.

greenish yellow glass forming the other double wedge is originally clear window glass which has been exposed in a southern window for about 15 years. The spectral transmittancy of the bluish green glass was found to be independent of the thickness of the wedge; this is to be expected from the uniformity of the glass; but the spectral transmittancy of the greenish

yellow glass was found to decrease as more of the glass away from the previous sunlight exposure area was included. This departure from linearity of spectral transmittancy with thickness was found, however, to be smaller than the experimental error of a single setting; accordingly an average straight line was drawn to approximate the function which required, strictly speaking, a line of some curvature to represent it. Fig. 3 shows the spectral transmission of 164 wedge units (2 thicknesses of about 7 mm. each) of the greenish yellow glass, and that of 98 wedge units (about 5.3 mm.) of the bluish green glass. These measurements were made on the König-Martens visual spectrophotometer[17] by Mrs. G. W. Haupt and Dr. K. S. Gibson.

These spectral transmissions have been combined with the spectral apparent reflectances of a number of representative comparison surfaces * to obtain a calibration of the instrument for a variety of colors. These cali-

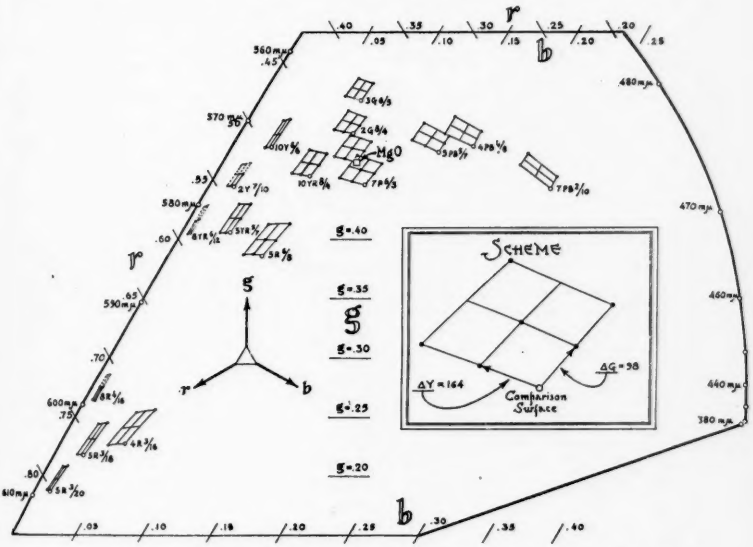


FIG. 4. Calibration of the subtractive colorimeter. The calibration is given on the uniform-chromaticity-scale triangle for all 17 comparison surfaces with which measurements have been made.

brations are shown in Fig. 4; from this figure may be read approximately the trilinear-coordinate differences corresponding to a given difference in wedge units for these comparison surfaces. Fig. 4 shows not only the effect of viewing the various comparison surfaces through 164 units of greenish yellow glass, but also through 328 units; and it shows similarly the effect of two

* Most of the spectrophotometric measurements on the comparison surfaces have been made by Mr. H. J. Keegan on the G.E. recording spectrophotometer.

thicknesses of the bluish green glass and combinations of the two types of glass. It should be noted from Fig. 4 that the lengths and directions of the vectors representing the trilinear-coordinate differences introduced by known amounts of the greenish yellow and bluish green glass undergo characteristic changes, with position on the triangle, almost independent of the spectral apparent reflectances of the comparison surfaces which happened to be chosen; that is, the window-shaped figure made up of these vectors varies in shape and size regularly with position on the triangle, and in a region close to two such figures the length and direction of the vectors could be estimated from either one with closely agreeing results. When the data are plotted to large scale, however, it is found, as expected, that the calibration is not strictly independent of the particular comparison surface; and, indeed, for one comparison surface (5R 6/8) the vector representing the effect of the first 98 units of the bluish green glass differed so definitely in direction from that representing the second 98 units that a curved line had to be drawn rather than a straight one. It is doubtless true that all of the lines should be drawn with some curvature, but the curvature for all but this one comparison surface is so slight that it has been neglected. Other slight failures of the calibration to be simply a function of position on the triangle may be noted for comparison surfaces identified by their Munsell equivalents as follows: 5R 3/20, 5R 3/18, 4R 3/16, 2Y 7/10, and 10Y 6/6. For all of these comparison surfaces the direction of the vector describing the effect of 328 units of the greenish yellow glass combined directly with the comparison surface differs definitely from the direction of the vector describing the effect of combining the same number of units of the same glass with a combination of the same comparison surface and 196 units of the bluish green glass. This changed direction is not to be accounted for by the slight shift in position on the triangle, but is instead characteristic of a sample of reduced spectral apparent reflectance in the long-wave region of the spectrum (see spectral transmission of the bluish green glass in Fig. 3). The unaltered direction is characteristic of the usual samples yielding these colors which do not have such reduced long-wave spectral apparent reflectance. With minor errors such as these, however, the calibration once found for a given region of the triangle can be applied to comparison surfaces of similar color. On this account, the spectral apparent reflectance of the comparison surface need be known only approximately. In this way it is possible to measure with good accuracy (errors of less than 0.3 unit of color difference) the differences between colors whose specifications themselves may be uncertain by as much as 20 units.

Inspection of Fig. 4 will indicate a disadvantage of the subtractive colorimeter. Even though it is not necessary to recalibrate the instrument for each new comparison surface, still a large amount of computation is required to cover in any adequate way the whole practical area of the triangle. Thus, 17 calibrations have so far been carried out, each requiring perhaps a whole working day of the time of one computer in addition to the time required to obtain the spectral apparent reflectances of the comparison surface; and there are still important gaps to be seen on the triangle in which reliable estimates of the calibration cannot be made without further computation.

Inspection of Fig. 4 also indicates a practical limitation of the instrument; it is not applicable to measurement of chromaticity differences be-

tween samples of too high selectivity of spectral apparent reflectance because light reflected by such samples is too little changed by passage through the wedges. This is indicated by decrease in the length of the vectors for the greenish yellow glass shown in Fig. 4 almost to zero for comparison surfaces (strong yellow and orange red) represented close to the spectrum between 580 and 610 mμ. A similar though not so marked decrease is indicated by the vectors for the bluish green glass for the comparison surface marked 7PB 2/10. Thus, the more closely the light reflected from the comparison surface is confined to a single region of the spectrum, the less convenient it is to measure chromatic departures from the sample by the subtractive colorimeter; and if the reflected light were entirely confined to a single region of the spectrum, the instrument could not be used at all because no adjustment, however great, of the wedges would produce any alteration in trilinear coordinates. For such a comparison surface the vectors would have zero length and the window-shaped figure giving the calibration would collapse to a single point.

(*Concluded in June issue.*)

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(*Continued on page 268.*)

# Textile Industry's Research Needs*

## Annual Fund of $25,000,000 Proposed

By FULLER E. CALLAWAY, Jr.†

AS I see it, the world and everything in it is divided into two major parts; first, the known and second, the unknown. Research is the work of endeavoring to change any part of the world from the unknown classification to the known classification.

Just as we divide the world and all things in it into two parts when thinking about research I like to divide all the people in the world into three parts when thinking about research.

First, we have those people who are satisfied with everything and everybody. We might call these the happy-go-lucky or Polyanna type. Unfortunately from the standpoint of day-by-day happiness and fortunately from the standpoint of progress, we have very few of this type of person.

Second, we have those people who are not satisfied with the old world of ours as it is but who are not willing to do anything constructive to change things, but just sit under the cork tree and "grip." These we call the "gripers." I think we all will agree that too large a part of our population comes within the definition of this second classification.

Third, we fortunately have a third classification, made up of those people who are dissatisfied with our old world as it is but who are willing to put their heart and soul into the task of improving the objectionable features. In this classification, we have our great doctors, teachers, lawyers, statesmen, and scientists. Research men and all men who are research-minded come under this third classification.

The man who first crossed an ocean, the man who first explored a continent, the man who first climbed a mountain, the man who first dug a hole into the earth, or who flew high among the clouds, was doing real research work just as much as the man who discovered electricity, the man who invented the radio, or the man who today sits at his desk in an air conditioned laboratory and looks through a microscope at objects which are invisible to the naked eye.

### Research Not Magic

So you see research in its broad sense is not as is frequently presumed some kind of magic which deals with complicated formulas, test tubes, and mysterious chemical reactions. Research was born with the first mental question mark and will continue so long as a man lives whose mind can con-

* Address at annual convention of American Cotton Manufacturers Association, New Orleans, La. Reprint from *The Journal of Commerce and Commercial*, April 17, 1939.

† President, Callaway Mills, La Grange, Ga., and of Cotton Manufacturers Association of Georgia.

ceive the question and whose hand and heart respond in an endeavor to find the answer.

Research, fact finding, changing the status of the unknown to the status of the known, can be applied to any problem. Research is a much more practical and satisfactory answer to a problem than "griping." To industry the fruits of research have been great, and to the people of our country have been given new necessities, new comforts, new conveniences, new aids to health and happiness, new leisure and new jobs.

Take any industry you like, study its history, and somewhere you will find the powerful and wholesome influence of research. Usually the industry has prospered and grown in proportion to the development of its research facilities.

The chemical industry has been developed in its entirety from research. The automobile industry could not have attained its present position without research. In 1920 there were only 500 industrial research laboratories in the United States whereas today there are 1,800. How many of these laboratories are operated by the textile trade? I am sorry to say very few of them.

I know what some of you are probably thinking. You are thinking about that old worn out theory that the textile industry is so old, that there is little left in the realm of the unknown, which, even if known, would be of aid to our industry. This is a sour grapes theory and its only value is to salve the conscience of the textile executives who are unwilling to change their classification from that of "gripers" to that third classification of "researchers."

## Praises Rayon Research

The fast growing strides of rayon prove what can be done in the textile industry when executives who are research-minded head the corporations involved. There are thousands of choice plums for the textile industry waiting in the realm of the unknown for some enterprising man to reach out and pull them back to his own profit. Also there is need for research in another division of our industry besides the need for technological research. We need the principle of research applied to our merchandising and distribution. Many questions with reference to our distribution and merchandising are immediately apparent the answer to which might be found through research. For example:

## Urges Selling Analysis

There is one question concerning the merchandising of textile products, the proper answer to which might well mean the difference between a profit and a loss for our industry. This question is "Should a mill which distributes its goods through a selling agent pay such selling agent (as is now customary) a percentage of the net value of the invoices or should the mill pay the selling agent for his part of the job a percentage of such mill's net profit?"

No doubt a sane discussion of this question by many mills with their selling agents would be difficult for some selling agents would probably "turn blue in the face" when this subject was mentioned.

There are probably two sides to this question and I can conceive great possibilities in the right answer being obtained to this question and the findings put into practical application. Certainly one argument in favor of the selling agent sharing in the mill's losses and mill's profits is that if this were the case, the selling agents would probably not be so content to go along month after month and even year after year, as is true in some cases, selling the mill's goods at a loss.

There are many other phases of merchandising research which should be undertaken. We need more research in our industry of all types. How will we get it, you say? The industry, unlike the automobile industry, is made up of a great multitude of individual units, the majority of which cannot afford the expense of operating a representative research program alone.

### Outlines Assessment Plan

My answer to this is simple—Why not organize our resources for strength and unity to fight through research our common competitive enemies such as paper, jute and metal? We have always been glad to contribute our money and time to fight against anything which threatened our industry. Why not contribute toward a fight for something? A fight for bringing our industry back into its flower through research. A unified fight.

If all the textile mills in the United States would pay an amount equal to 1 per cent of their net invoices into a fund to promote research on a broad front, we would have a fund of approximately $25,000,000 a year and it wouldn't cost any individual mill a cent of profit if we all did it. All other industries combined in the United States are spending approximately $200,000,000 a year on research. A textile research project costing $25,000,000 a year would enable the textile industry to not only get on its feet but to soon be riding the crest of the wave.

I for one stand ready to join hands with the rest of the industry and to contribute our 1 per cent whenever the balance of the mills will join me.

## A $25,000,000 Plan

*Under this heading the May issue of "Textile World" carries an interview with Mr. Callaway in which, while admitting that he has not formulated a definite research plan, he advances further constructive suggestions and indicates a modified basis for starting the financing.*

"A BREATH-TAKING proposal—and one which captured the imagination of his hearers—was advanced by Fuller E. Callaway, Jr., president of Callaway Mills, La Grange, Ga., in his address at the New Orleans meeting. He suggested a fund of $25,000,000 a year to promote textile research.

"When questioned subsequently by the editor of *Textile World* regarding details of his proposal, Mr. Callaway stated that, while he had not formulated any definite plan, he thought the research laboratory should be operated by a full-time, paid board—such board being appointed so that one or more members would represent each branch of the textile industry.

The board members could be selected by, and work closely with, the various trade associations already in existence, he added. An important feature suggested by Mr. Callaway is that patents developed by this research laboratory would be licensed only to those mills contributing to the expense.

"As to the minimum income with which to start, and the general method of financing, he feels that mills should be signed up on a five-year basis, the plan to become effective when some stated percentage of the industry had signed up. He suggests further that contributions could be on the basis of one-tenth of 1% of each mill's net shipments for the first year; one-quarter of 1% for the second year; one-half of 1% for the third year; three-quarters of 1% for the fourth year; and 1% for the fifth year, representing the full amount suggested by him at New Orleans."

* * *

## Editorial Comment

*In the same issue of "Textile World," Editor Douglas G. Woolf, who is a director and member of the executive committee of U. S. Institute for Textile Research, comments as follows on the Callaway proposal:*

"AS one who has urged organized cooperative research in the textile industry for a score or more of years, we naturally hail Fuller E. Callaway's proposal for a $25,000,000 annual fund for that purpose as one of the most important suggestions made in recent years.

"We know that some will shudder at the magnitude of the plan. Personally, we feel that what this industry needs is magnitude. Most of its projects are on too piddling a scale.

"It is interesting to recall that Mr. Callaway's brother—Cason J. Callaway—some years ago proposed a cotton industry promotion plan involving some millions of dollars. Many of his hearers thought he was soaring too high. And yet, we are confident that if a program of that size, properly conceived and administered, had been launched at that time, many of the present problems of the industry would be non-existent.

"Fuller Callaway has an open mind on details of the plan, but does have some broad suggestions, as will be noted in the *Textile World* interview with him elsewhere in this issue. We urge that the industry think carefully about this proposal—and derive a thrill, rather than a fright, from the $25,000,000 phase of it."

* * *

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(*Continued from page 263.*)

11. D. B. Judd. A Maxwell Triangle Yielding Uniform Chromaticity Scales. *B. S. J. Rsch., 14,* 41 (1935), RP 756; *J. Opt. Soc. Am., 25,* 24 (1935).

12. D. L. MacAdam. Maximum Visual Efficiency of Colored Materials. *J. Opt. Soc. Am., 25,* 361 (1935).

13. R. S. Hunter. Problems in the Development of a Multiple-Purpose Reflectometer. *J. Opt. Soc. Am., 27,* 225 (1937).

14. D. B. Judd. A Subtractive Colorimeter for the Measurement of Small Chromaticity Differences Between Surfaces of Moderate Spectral Selectivity of Reflectance. *J. Opt. Soc. Am., 26,* 225 (1936).

15. A. C. Hardy and O. W. Pineo. The Computation of Trichromatic Excitation Values by the Selected Ordinate Method. *J. Opt. Soc. Am., 22,* 430 (1932).

16. R. S. Hunter. Development of Filters for Tristimulus and Luminosity Measurements with Barrier-Layer Photo-Cells. *J. Opt. Soc. Am., 28,* 51, 179 (1938).

17. H. J. McNicholas. Equipment for Routine Spectral Transmission and Reflection Measurements. *B. S. J. Rsch., 1,* 793 (1928), RP 30.

# Abstracts

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## I. Fibres (Synthetic and Natural) and Fibre Analysis

Albene and Rhodia Staple Fibres: Properties. R. Genazzani. *Textilia*, 1937, V. 13, P. 511; abs. in *J. T. I.*, July 1938, P. A425.

Albene (matt) and Rhodia (silky) staple fibre are made of cellulose acetate and have the following properties: (1) Greater resistance to water than other artificial fibres, (2) very low inflammability, (3) small conductivity for heat and good electrical insulating properties, (4) low specific gravity, 1.27 against 1.54 for the other cellulose fibres, (5) special affinity for dyes, through which good two-color effects can be obtained. These fibres are usually mixed with others in the proportion of 15 to 45% to give improved dyeing effects. The advantages of adding various percentages of Albene to other fibres are discussed. (C)

Animal Fibres: X-ray Structure and Elastic Properties. H. J. Woods. *Proc. Roy. Soc.*, 1938, V. A166, P. 76–96; abs. in *J. T. I.*, July 1938, P. A426. (C)

Cell Membrane of Cotton Fibre in Cuprammonium Hydroxide Solution: Behavior of. Wanda K. Farr. *Contrib. Boyce Thompson Inst.*, 1938, V. 10, No. 1, P. 71–112.

Author's summary: The cellulose component of the cell membrane of the cotton fibre, which is in the form of diminutive cellulose particles, does

not dissolve in the standard solution of cuprammonium hydroxide, specified by the American Chemical Society, to produce the viscosities commonly attributed to it. The fibre is transformed by the cuprammonium hydroxide into a swollen, viscous mass of cementing material in which the cellulose particles are dispersed. The separated cellulose particles from which the cementing material has been removed will not produce viscosities in cuprammonium hydroxide. One component of the cementing material, the pectic fraction extracted with ammonium oxalate, will produce viscosities in the same solution to the point of formation of a stiff gel. These observations alter our previous conceptions of the behavior of both untreated and purified cell membranes in solutions of cuprammonium hydroxide. It is now clear that the viscosity-producing power of the cementing material, or of any one of its fractions, has been overlooked as has been also the presence in the cuprammonium solution of the cellulose in the form of diminutive particles of uniform size and shape, still undissolved, and merely in a state of dispersion.

CELLULOSE: DEGRADATION IN VISCOSE PROCESS. A. Lottermoser and F. Wultsch. *Kolloid Z.*, 1938, V. 83, P. 180–96; abs. in *J. T. I.*, Aug. 1938, P. A465. (C).

HEAT CONTENT OF WATER SORBED ON CELLULOSE. J. H. Shipley, W. B. Campbell, and O. Maass. *Canadian J. Rsch.*, May 1937, Vol. 15, P. 224–8; abs. in *Eastman Kodak Abs. Bull.*, Nov. 1938.

The specific heat of cellulose has been determined for the temperature range — 70° to 25° C. The heat capacity of water sorbed to the extent of 5.92 and 12.0% by cellulose has been determined for the range — 78.5° to 25° C. These data are compared with the heat capacity of pure water for the same temperature range, namely — 78.5° to 25° C. (S)

ITALIAN RAYON AND STAPLE FIBRES: PROPERTIES. E. Viviani. *Textilia*, 1937, V. 13, P. 505–9; abs. in *J. T. I.*, July 1938, P. A426.

A table is given of the strengths of wool, silk, ramie, rayon and other artificial fibres in comparison with cotton and a diagram of load-extension graphs. Dry Tenax staple fibre has the same strength as American cotton and a higher breaking load when wet than wool when dry. A special rayon has been produced with a tenacity in the wet state superior to that of cotton. (C)

MILK-WOOL: DISSOLVING ACTION OF MICRO-ORGANISMS ON. J. Smit and B van der Heide. *Nature*, 1938, V. 141, P. 647–8; abs. in *J. Soc. Dyers Col.*, Aug. 1938, P. 396.

Nearly all casein-splitting organisms isolated from soil or manure, or gathered by infection from the atmosphere, are able to attack "milk-wool." They act by an exo-enzyme, and therefore the "wool" is dissolved over a fairly wide area round their place of growth. (C)

STAPLE FIBRE: OUTLOOK FOR. G. Nitschke. *Kunstseide u. Zellwolle*, 1937, V. 19, P. 434–7 (through *C. A.*, 1938, V. 32, Col. 3621); abs. in *J. T. I.*, July 1938, P. A389.

A general review of the difficulties of mixing staple fibre with wool, mainly with regard to the dyeing of the resultant fabric. The goal be-

fore the industry is to produce staple yarn with stable curl, better resistance to water and "animalization" of the fibre by the addition of nitrogenous substances to the spinning solution or the surface of the fibre. (C)

WOOL: FINE STRUCTURE OF. SUBMICROSCOPIC STRUCTURE OF MERINO WOOL INDICATED BY DYEING. K. Ohara. *Mell. Textilber.*, 1938, V. 19, P. 407–8; abs. in *J. Soc. Dyers Col.*, Aug. 1938, P. 395.

Microscopic investigation of merino wool has indicated that one-half of the cortical layer is dyed more intensely with basic dyes than the other half. This is attributed to the fine structure of the cortical layer, which is governed mainly by the structure of the hair follicles and the hair growth. It is concluded that the cortical layer of merino wool possesses a stronger negative charge on the exterior curve of the curl than inside the curl, in spite of the fact that, on account of its amphoteric nature, the cortical layer is dyed uniformly with negatively charged acid dyes. (C)

## II. YARNS AND FABRICS

CARD STRIPPING USING ELECTROSTATIC INDUCTION. Casablancas High-Draft Co., Ltd., Manchester, Eng. *Text. Mfr.*, Nov. 1938, P. 485.

A new device whereby static electricity is utilized to reduce stripping in cotton carding. (C)

COMBING OF GOOD QUALITY INDIAN COTTONS: FURTHER TESTS ON THE. Nazir Ahmad. Indian Central Cotton Committee Technological Bulletin Series A, No. 44, Aug. 1938, 25 pp.; abs. in *Text. Mfr.*, Dec. 1938, P. 512, 531.

Combing of good Indian cottons (⅞ in. or 1 in. staple) proved technically valuable at waste extractions of 8% or 25%, but the investigation proved that the mean length was no greater than that of the lint. (C)

CREASING AND CREASEPROOFING: THEORY OF. Kurt Quehl. *Mell. Textilber.*, 1939, No. 1, P. 76.

The assumption appears to be justified that the crease-resisting properties of textile fibres are closely connected with their structure and that they are more liable to crease when the crystalline structure is more pronounced and the greater the extent to which they show orientation. Thus the tendency to crease rises progressively throughout the series wool—real silk—acetate rayon—viscose—cuprammonium—cotton—bast fibres. Creaseproofing by the Preska or the Tootal process proceeds in accordance with that theory and consists in artificially augmenting the non-crystalline substances in the intermicellar interstices with the aim of reducing the possibility of parallel arrangement of the micellae upon deformation, so that the crease-resisting properties of a cellulose fibre can be improved all the more readily, the larger the intermicellar space at disposal for such treatment. (C)

TWIST VARIATIONS IN CAP SPINNING. Donald Wilson. *Wool Record & Text Wld.*, Sept. 8, 1938, P. 553–9.

Their causes and prevention in worsted spinning are discussed. (C)

VISCOSE RAYON IN THE TEXTILE INDUSTRY: RECENT DEVELOPMENTS IN USE OF. A. E. Delph. *J. Soc. Dyers Col.*, Aug. 1938, P. 366–71. (C)

SCREEN PRINTING: NEW METHODS OF. A. Franken. *Silk & Rayon*, 1938, Oct., P. 940–4; Nov., P. 1052–4; Dec. 1938, P. 1127–8, 1156. (C)

VARIABLE-COUNT YARNS: APPLICATION. E. Braschler. *Leipz. Monats. Text. Ind.*, 1938, V. 53, P. 123–6; abs. in *J. T. I.*, Sept. 1938, P. A532.

Apart from the effects produced by the use of knop, flake and other fancy yarns, pleasing effects in fabrics can be obtained simply and cheaply by the use of yarns spun from mixtures of materials of different nature or color or by the use of yarns in which the count varies. The latter type of yarn is discussed and the influence of the length of the repeat twist, maximum, minimum and mean counts, and the ratio between the maximum and minimum counts in a given yarn is studied. A curve showing the variations in counts in a typical yarn of this type is given and the adaptation of a ring spinning machine for the production of this type of yarn is briefly described. Precautions to be taken in weaving and finishing processes are indicated. Applications of variable-count yarns as warp and weft are discussed and samples of imitation linen and raw silk fabrics prepared from Vistra staple fibre yarns showing count variations are given. (C)

WARP KNITTING ON LOCKNIT LOOMS: MODERN TRENDS IN. J. B. Lancashire. *Silk J. & Rayon Wld.*, Jan. 1939, P. 27–8. (C)

WEAVING: EXPERIMENTAL INVESTIGATIONS OF SHUTTLE FLIGHT DURING. R. McK. Kilgour, R. Waring and H. Boffey. *J. T. I.*, Aug. 1938, P. T173–T194.

A method of investigating the acceleration of the shuttle during the development of the pick is described, in which an actual space-time curve of shuttle motion is obtained as a photographic record. This is done by means of an electrical resistance fixed to the loom and a cathode ray oscillograph with suitable time-base. The exact motion of the shuttle through the shed after leaving the picker has not been followed, but the time of arrival at the far box has been recorded by a simple mechanical attachment to the loom behind the shuttle-box swell, and this device is shown to be also capable of giving other useful information regarding the retardation period of the shuttle entering the box. From the results of these two portions of the investigation, values of average shuttle speed have been calculated, and this has been done over a range of loom speeds from 100 to 220 picks per minute. Over this range, it has been found that the average velocity of the shuttle from leaving the picker to reaching the opposite swell is nearly proportional to loom speed. The shuttle velocity attained during the development of the pick is much greater than would be calculated from the "geometry" of the picking mechanism and the speed of the loom. The considerable extra shuttle speed developed is due to the "catapult action" of the picking stick derived from stretched connecting leather and bent stick. It was found that the extra speed thus gained is itself proportional to the loom speed. Under the conditions obtaining in these experiments, the acceleration of the shuttle was found to

be far from uniform. The retardation in the far box was not measured, but calculations made from the swell motion records show that at all ordinary loom speeds the shuttle suffers no appreciable retardation between hitting the swell and coming up against the picker near the back of the box. (C)

## III. Chemical and Other Processing (Not Otherwise Classified)

Acid Dyeing of Wool: Theory of. E. Elöd and H. Reutter. *Mell. Textilber.*, 1939, No. 1, P. 57.

The authors have examined wool treated with alkalis under the most diverse conditions and thereby determined the position of the isoelectric point, the rate of dyestuff absorption, the acid and dye acid combined in equilibrium, and the sulphur content. It was found in every case that not only the speed of absorption of dye acid, but also the amount of dyestuff combined in equilibrium increased parallel with displacement of the isoelectric point towards alkaline values, while the sulphur content of these samples dropped. At pH values of 4.7 and 7.3, wool absorbs only 1% of the acid dyestuff Crystal Ponceau. When wool dyed in that way is treated with water of the same pH value, about 0.5 or 0.6% of the dyestuff are rinsed out again, so that only about 0.6 or 0.3% of dyestuff remains in combination, while about 20% can be absorbed by the wool substance when dyeing is carried out in a bath with a pH value of 1.3, other conditions being the same. Only about 2.3% of Orange GG (calculated on the weight of the fibre) is absorbed by wool at pH = 7.2, and 0.6% of the dye are removed by washing, leaving a dyestuff content of about 1.7%. Upon dyeing wool with Orange II under the same conditions, an absorption of 5.7% was found in the condition of equilibrium, of which 4.9%, however, could be removed by treatment with water of the same pH value of 7.1, so that the amount of dye absorbed amounted only to about 0.8%. (C)

Anti-crease Processes for Viscose Rayon. C. H. S. Tupholme. *Text. Col.*, May 1938, P. 335. (C)

Benzidine Dyes: Constitution and Substantivity. W. Schramek and H. Rümmler. *Kolloid-Beihefte*, 1937, V. 47, P. 133–95; abs. in *J. T. I.*, Aug. 1938, P. A484. (C)

Bibliography on Methods for Determining the Causes of Damage Appearing in Wool after Dyeing. B. A. Ryberg. *Am. Dye. Rptr.*, Oct. 17, 1938, P. 571–602. (C)

Bleaching of Cellulose. J. Elm's. *Rev. gén. mat. plastiques*, Feb. 1938, V. 14, P. 37–41; abs. in *Eastman Kodak Abs. Bull.*, Nov. 1938.

The various methods of bleaching cellulose are reviewed, special attention being given to the hypochlorite process. The reactions involved, the effect of temperature, acidity, and density of cellulose material and catalysts on the bleaching process and the chemical and physical changes produced by bleaching are discussed. (S)

BLEACHING COTTON KNIT GOODS. L. P. London. *Am. Dye. Rptr.*, Oct. 31, 1938, P. 627–28. (C)

BUFFER ACTION IN CLOTH SCOURING. G. L. Atkinson. *Text. Merc.*, 1938, P. 494; abs. in *Rayon Tex. Mo.*, Dec. 1938, P. 95.

A test was made on the hydrogen ion concentration of borax and borax with soap. A table showing the results is given. With the addition of borax, equilibrium pH values were reached quickly, but in the absence of borax the pH values rose to an indefinite extent. (C)

CELLULOSE DERIVATIVE: NOTES ON PROCESSING WOOLEN AND OTHER STOCK SIZED WITH A. S. Wouble. *Text. Col.*, Aug. 1938, P. 523–24. (C)

COLORIMETRIC CHANGES RESULTING FROM VARIATIONS IN THE CONCENTRATION OF DYE SOLUTIONS. M. O. Pelton. *J. T. I.*, Oct. 1938, P. T227–T238.

The colorimetric effects of change of concentration of a number of dye solutions are calculated in terms of hue wave-length, saturation and brightness. It is shown that a just perceptible small change of concentration is visible to the eye in virtue of the change it produces in the brightness factor of the specimen, while the accompanying changes in hue wave-length and saturation are negligibly small. The amount of this change in brightness factor resulting from a given small change in concentration varies with the color of the specimen and increases in the order yellows, oranges, reds, greens and blues. The least perceptible percentage change of concentration is dependent on the absolute concentration and is less for dark shades of color than for pale shades; estimated values for fairly dark shades of the different colors are Yellows 5.4, Oranges 1.7, Reds 1.6, Greens 1.1, and Blues 0.9%. It is claimed that these results have a direct bearing on the fading of dyed materials and the unlevel dyeing of fabrics. (C)

COPPER COMPOUNDS: FUNCTION OF—IN TEXTILE TECHNOLOGY J. Wakelin. *Text. Col.*, Oct. 1938, P. 659–60, 706. (C)

COTTON AND STAPLE FIBRE MIXTURE YARNS: MERCERIZATION. W. Schramek. *Leipz. Monatsh. Text. Ind.*, 1938, V. 53, P. 106–8, 129–33; abs. in *J. T. I.*, Oct. 1938, P. A599. (C)

COTTON AND VISCOSE RAYON DYES: LEVEL-DYEING PROPERTIES. W. Weltzien and K. Windeck-Schulze. *Monatsh. Seide u. Kunstseide*, 1938, V. 43, P. 156–62, 189–94; abs. in *J. T. I.*, Aug. 1938, P. A482. (C)

DETERGENCY: ADDITIVE EFFECT OF BUILDERS IN. J. Fred Oesterling. *Am. Dye. Rptr.*, Oct. 31, 1938, P. 617–20.

Paper presented before Philadelphia Section, A. A. T. C. C., April 22, 1938. (C)

DETERGENCY: FACTORS CONTRIBUTING TO. L. P. Hall. *Am. Dye. Rptr.*, Oct. 31, 1938, P. 612–16.

Paper presented before Philadelphia Section, A. A. T. C. C., April 22, 1938. (C)

## IV. Research Methods and Apparatus

Dyed Textiles: Fastness to Light; Measurement. E. W. Pierce. *Rayon Tex. Mo.*, 1938, V. 19, P. 249, 263; abs. in *J. T. I.*, July 1938, P. A428.

The author criticizes present methods of measuring fastness to light, and emphasizes the need for a universal method of reporting fastness to light that is not dependent on personal opinion or personal judgment. A table compares the German standards in terms of sun-hours (determined by Ris), in terms of Krais's paper strips tinted with Victoria blue, and in the calculated equivalent hours of the standard American Fadeometer. The figures show that the steps are not in the ideal geometrical progression and that Group 8 represents an exposure of 128 hours according to the U. S. Bureau of Standards, 138.5 hours according to Krais and 280 hours according to Ris. The problem presented by yellow dyes that redden is mentioned. (C)

Electron Microscope and its Applications. Ruska, Borries, and F. Krause. *Umschau*, 1938, V. 42, No. 34, P. 766–68, 769–71; abs. in *Eastman Kodak Abs. Bull.*, Nov. 1938.

A short and simple description is given of the new electron microscope built by Siemens and Halske A.-G. After explaining the principles utilized in its design, the authors describe different applications in the fields of biology and colloid chemistry, and show pictures that have been obtained with the microscope, using magnifications up to 40,000 times. (S)

Fibre Characteristics. Wm. M. Grosvenor, Jr. *Text. Wld.*, Aug. 1938, P. 64.

The article and its illustrations emphasize the advantages of proper relation between optical properties of mounting media and textile fibres in microscopic examination and analysis. In the case of rayon fibres it is shown that use of monobromnaphthalene mounting accentuates the striations in the bright fibres and the pigmentation in the dull fibres, also clarifying fibre edges; also the use of mounting media which has the same refractive index as the fibre renders the latter invisible. (C)

Fibres: Bending Test; Application. (1) H. J. Henning. (2) W. Schramek. *Leipz. Monats. Text. Ind.*, 1938, V. 53, P. 101–5; abs. in *J. T. I.*, July 1938, P. A424.

(1) The author replies to criticisms of the fibre bending test made by Schramek and Hempel and points out the usefulness of this test in the evaluation of staple fibres. (2) In a reply to the above, the author discusses the factors influencing the resistance of fibres and yarns to repeated bending and points out the difficulty of obtaining reproducible results. The results of tests are quoted to show the high scatter of the values. The scatter is much greater in fibre tests than in yarn tests and even in the latter it is much higher than that observed in ordinary strength tests. The need for clearer definition of the test, of the fibre properties influencing the bending process, and of the relation of the results to the behavior of fibres in processing and in use is emphasized, and the influence of the form and motion of the clamp on the bending of the fibre is discussed. (C)

FINISHING AGENTS: DETECTION IN ULTRA-VIOLET LIGHT. F. Schröder. *Leipz. Monats. Text. Ind.*, 1938, V. 53, P. 112–14; abs. in *J. T. I.*, July 1938, P. A429. (C)

FINISHING AGENTS: DETECTION ON RAYON AND STAPLE FIBRE. F. Ohl. *Kunstseide*, 1938, V. 20, P. 230–31; abs. in *J. T. I.*, Oct. 1938, P. A610.

Procedures for the detection of fats, fat and oil preparations, linseed oil sizes and glycerin on rayon and staple fibre are outlined and the preparation of a series of reagents for use in the detection of various organic finishing agents is briefly described. A table showing the reaction of these reagents with aqueous extracts containing dextrose, dextrin, starch, tragacanth, gelatin, glue, proteins, Iceland moss and British gum is given. (C)

FLUORESCENCE ANALYSIS IN ULTRA-VIOLET LIGHT AS APPLIED TO DYED AND FIBROUS MATERIALS. J. Grant. *J. Soc. Dyers Col.*, Aug. 1938, P. 361–66. (C)

PHYSICAL AND CHEMICAL TEXTILE TESTING. John H. Skinkle. XI, Part II. Chemical Testing, Organic Extraneous Matter. *Am. Dye. Rptr.*, Sept. 5, 1938, P. 483–6; XII, Part II. Fibre Mixtures. *Ibid.*, Nov. 14, P. 638–40, 657–60. (C)

PRACTICAL TESTING. L. B. Tansley. *J. Soc. Dyers Col.*, Sept. 1938, P. 413–21.

The subject in the present paper is confined principally to work in connection with the inspection and examination of cloth from the point of view of the dyer and finisher, and particularly to color matching, fastness, etc. Methods of testing and of correcting defects in dyed and finished goods are discussed. (C)

RAYON STAPLE FIBRE: RESISTANCE TO BENDING. H. J. Henning. *Leipz. Monatschr. Text. Ind.*, 1938, V. 53, P. 165–6; abs. in *J. T. I.*, Oct. 1938, P. A617.

In reply to Schramek's criticisms of the accuracy of bending tests on fibres, the author submits data and claims that the scatter of the results is not greater than in yarn tests. Other criticisms are also considered. (C)

SHEEN GLOSSMETER. E. E. Jelpke. *J. Sci. Instr.*, 1938, V. 15, P. 181; abs. in *J. T. I.*, Aug. 1938, P. A513.

A "Sheen Glossmeter" for comparative measurement of the gloss or mattness of paint, varnish, lacquer or other surfaces is described. The device consists of a lamp unit with condenser and diaphragms, the base casing which is arranged for accurate location of test samples irrespective of size, and a photo-cell tube, containing a special photo-cell. A standardized test-plate is supplied, which represents 100% gloss. The "Sheen Transformer" to be used with the glossmeter gives very fine control of voltage to the lamp and tends to reduce voltage fluctuations in the mains. (C)

STANDARD ATMOSPHERE. W. H. Whitcomb. *Rayon Tex. Mo.*, Oct. 1938, P. 41–2.

The author discusses the proposal to change the requirement of the standard atmosphere from 65% relative humidity to 55% for testing rayon and concludes that it has no advantages, and obvious disadvantages. (C)

STAPLE FIBRE: TESTING. H. Böhringer. *Klepzig's Textil Z.*, 1938, V. 41, P. 214–9; abs. in *J. T. I.*, July 1938, P. A426.

A general account is given of methods of determining the fineness, staple, strength, extensibility, elasticity, resistance to repeated bending, curl, stability of curl, etc., of staple fibre. Typical results are given for German cotton- and wool-like staple fibres and are compared with the results of tests on cotton, wool and silk. (C)

STARCHES: MODIFIED. THEIR DEGRADATION BY POTASSIUM DICHROMATE. G. B. Jambuserwala. *J. T. I.*, July 1938, P. T149–T160.

It is claimed that starches modified as suggested in this paper provide sizing material in which several of the inherent drawbacks of the raw starch are absent. All the four varieties of starches (corn, farina, sago, wheat) gave increased tensile strength values of yarns when sized with them; also corn, sago and farina imparted improved stiffness. It is observed that farina and sago do not need to be treated with the fourth and fifth concentrations of the oxidizing mixtures, because at these stages they are found to be too greatly dextrinized to be useful for textile purposes. It is expected that modification of starch to a lesser degree than what has been suggested in the present paper would, in all probability, give products more suited to textile operations and would more adequately replace the raw starch. (C)

STRAINED YARNS: CAUSES AND EXAMINATION. *Text. Wkly.*, 1938, V. 21, P. 690–1; abs. in *J. T. I.*, July 1938, P. A428.

Causes of strain on yarns in winding, warping and sizing processes are described and methods of prevention are indicated. The difficulty of observing straining is discussed and it is pointed out that the most suitable instrument for this purpose is a photocopier which is described. (C)

WOOL: PURIFICATION OF—FOR EXPERIMENTAL PURPOSES. S. R. Trotman and D. E. Stocker. *J. T. I., July* 1938, P. T145–T147.

The authors have found that purification of wool may be simplified by removing alkali with an alcoholic solution of oleic acid, which makes it possible to use sodium carbonate for the neutralization of acid. The process as applied to raw Botany wool and Botany tops is described. (C)

WOOL: DETERMINATION OF ALKALI IN. S. R. Trotman and D. E. Stocker. *J. T. I.*, July 1938, P. T148.

Wool containing alkali and soap is treated with an alcoholic solution of oleic acid, the free alkali converted into soap and soap being unaffected. If a standard solution of oleic acid be used the alkali can be determined by titration. The method is carried out as follows: A weighed quantity of the wool (1 to 2 grams) is treated with a known volume of

the oleic acid solution in a small beaker, which is heated on a water bath until the alcohol has evaporated and carbon dioxide expelled. The contents of the beaker are then placed in the chamber of a continuous extractor, and the beaker washed out several times with small quantities of alcohol. More alcohol is added and the wool is extracted at the boiling point for about one hour. The liquid in the flask is boiled on a water bath for a few minutes to ensure absence of carbon dioxide and titrated with 0.1*N* alcoholic potassium hydroxide solution in presence of phenol phthalein. The oleic acid solution is titrated also, and the alkali obtained by difference. A sample of Botany top (alkaline to phenolphthalein) gave 0.31%, 0.31%, 0.33%. (C)

(Yarn and Cloth) Comparative Analysis. Ronald E. Booth. *Text. Rec.*, Oct. 6, 1938, P. 110–1.

Precautions to be observed in testing material against a standard sample or figures of previous tests when only small samples are available. (C)

Yarn Testing: Effect of Tension and Speed in. R. E. Booth. *Text. Rec.*, Dec. 6, 1938, P. 20–1.

Tabulates and discusses the differences in the results of tests carried out at different tensions and different speeds. (C)

Yarn Twist Tester. *Silk J. Rayon Wld.*, 1938, V. 14, No. 167, P. 39; abs. in *J. T. I.*, July 1938, P. A427.

The "MDD" electrically-operated twist tester is described. (C)

X-ray Photography: Application in Textile Investigations. B. E. Luboshez. *Photographic J.*, 1938, V. 78, P. 275–85; abs. in *J. T. I.*, July 1938, P. A429.

A report of a lecture giving a simple account of X-rays and the practical uses to which they have been put. X-rays of unusually low penetrating power known as "Grenz" rays, generated in special low-voltage X-ray tubes fitted with a very thin glass window, are used for the examination of paper, leather and textiles. By loading textiles with different kinds of heavy salts it is possible to obtain characteristic radiographs that show the positions and tightness of individual threads. An illustration is given of the effect of the boil-off and similar processes in producing crêpe. (C)

## V. Pure Science, Economics and Misc.

Cellulose: Hydrolysis. M. L. Wolfrom, L. W. Georges and J. C. Sowden. *J. Am. Chem. Soc.*, 1938, V. 60, P. 1026–31; abs. in *J. T. I.*, Aug. 1938, P. A509.

A 5% solution of cellulose in fuming hydrochloric acid was kept at 16° and the course of the hydrolysis followed polarimetrically up to 3 hours. Samples were also removed at various intervals and mercaptalated with ethyl mercaptan. Precise sulphur analyses were made on the products and they were also hydrolyzed and the viscosities of the regenerated celluloses in cuprammonium solution were determined. An exactly simi-

lar set of experiments was then performed on another lot of the same cotton linters, except that the mercaptalation was omitted. The copper numbers of the mercaptalated hydrolyzed celluloses ranged from 1.8 to 5.5 and of the non-mercaptalated hydrolyzed celluloses from 5.0 to 28.4. The degrees of polymerization in glucose units are calculated from the sulphur analyses on the mercaptalated products and also from the cuprammonium viscosities; the results are tabulated. A determination has also been made of the viscosity changes taking place at 16° in a 5% cellulose solution in fuming hydrochloric acid with increasing time of hydrolysis. (C)

COLLOIDAL SOLUTIONS: INFLUENCE OF ULTRASONIC WAVES ON VISCOSITY. H. Freundlich and D. W. Gillings. *Trans. Faraday Soc.*, 1938, V. 34, P. 649–60; abs. in *J. T. I.*, Aug. 1938, P. A512. (C)

COLOR: ITS CHARACTER, SYNTHESIS AND MEASUREMENT. I–VI. *Silk & Rayon*, 1938, April, P. 357–8; May, P. 472–3; June, P. 562–3; Aug., P. 750–2, 760; Oct., P. 952; Nov., P. 1056–7. (C)

COLOR MEASUREMENT: FUNDAMENTALS OF. D. L. MacAdam. *J. Soc. Mot. Pict. Eng.*, Oct. 1938, P. 343–8; abs. in *Eastman Kodak Abs. Bull.*, Nov. 1938.

Communication No. 669. Standard I. C. I. color specifications can be computed from spectrophotometric data. The fundamental relations that are used to define the quantities in terms of which colors are specified are most concisely expressed in mathematical formulae, which are simply explained. (S)

DEXTRIN AND SOLUBLE STARCH: ELECTRO-CHEMICAL PROPERTIES. W. Pauli, J. and St. Szper. *Kolloid Z.*, 1938, V. 82, P. 335–44; abs. in *J. T. I.*, July 1938, P. A436. (C)

DRYING AND AIR CONDITIONING EQUATIONS: REVIEW. E. R. Gilliland. *Ind. Eng. Chem.*, 1938, V. 30, P. 506–14; abs. in *J. T. I.*, Aug. 1938, P. A504.

The basic equations for the rate of heat and mass transfer are reviewed, with special reference to drying and air conditioning. The mass transfer coefficients are considered in the light of the film and turbulent-core concepts and on the basis of empirical equations. Owing to the lack of knowledge of the mechanism of fluid motion through solids, the application of the diffusion equation in drying problems is questionable. (C)

EXPERIMENTAL DATA: LAW OF ERROR AND COMBINATION OF OBSERVATIONS. H. Jeffreys. *Phil. Trans. Roy. Soc.*, 1938, V. A237, P. 231–71; abs. in *J. T. I.*, Aug. 1938, P. A508. (C)

ELECTROCHEMICAL NATURE OF CELLULOSE ESTERS. A. Dobry. *J. chim. phys.*, Jan. 1938, V. 35, P. 16–19; abs. in *Eastman Kodak Bull.*, Sept. 1938, P. 424.

The acetone solutions of cellulose derivatives (di- and trinitrocellulose, di- and triacetylcellulose) are always conductors. The apparent conduc-

tivity of the cellulose esters increases with the degree of purification (by dialysis), finally attaining a constant value. This conductivity limit is very small; the highest figure obtained is $12.48 \times 10^{-6}$ at 20° for a solution 4.08 per cent by weight. It is proportional to the concentration, which always remains small (from 0.5 to 6%). The mechanism of the conductance cannot be established for certain. It could be explained by the existence, in each molecule, of a weakly ionized group, but a purely electrokinetic phenomenon could also be invoked as the explanation. (S)

FOAMINESS: UNIT OF. J. J. Bikerman. *Trans. Faraday Soc.*, May 1938, V. 34, P. 634–38; abs. in *Eastman Kodak Abs. Bull.*, Oct. 1938.

An attempt is made to establish the foaming capacity of a solution as a physical quantity. This quantity, with the dimension of time, is defined as the mean life of a bubble in the foam and is, with certain restrictions, independent of the apparatus and technique employed. (S)

FREQUENCY DISTRIBUTIONS: APPROXIMATE NORMALIZATION. J. B. S. Haldane. *Biometrika*, 1938, V. 29, P. 392–5; abs. in *J. T. I.*, Sept. 1938, P. A565.

The author discusses transformations of $\chi^2$ and the variate of a binomial series that have distributions converging more rapidly to the normal as the size of sample increases than the untransformed variate. The transformations are intended to be used when expectations are small. (C)

GELATIN: AMINO-ACID ANALYSIS. N. I. Gawrilow and M. A. Poulounina. *Bull. Soc. Chim. France*, 1938, V. 5, P. 454–9; abs. in *J. T. I.*, Aug. 1938, P. A509.

Blanchetière in 1927 proposed a method for separating the diketopiperazines from the amino acids in a protein digest by means of the barium salts of the carbamates of the latter. Some doubt exists about the behavior of proline and oxyproline in this scheme. The authors have studied this point with reference to the hydrolysis of gelatin (containing about 30% of the prolines), and report that, like the *α*-amino-acids, the prolines are recovered almost quantitatively in the precipitated barium salt, the anhydride fraction containing a mere trace. (C)

GLYCEROL: DETECTION. O. Frehden and Chen-Hua Huang. *Milrochimica Acta*, 1937, V. 2, P. 20–3; abs. in *J. T. I.*, Aug. 1938, P. A509.

Two micro-tests for glycerol are described. (1) The liquid is heated with crystalline oxalic acid and the carbon dioxide evolved is detected by means of a phenolphthalein and sodium carbonate test paper. (2) The monoformin obtained in the oxalic acid reaction is mixed with alcoholic hydroxylamine hydrochloride, made alkaline with alcoholic alkali and heated to form the hydroxamic acid salt, and this is detected as the violet ferric salt on adding acid and ferric chloride. (C)